

APPLICATION FOR UNITED STATES LETTERS PATENT

for

ENDOSCOPIC CLIP APPLIER AND METHOD

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ENDOSCOPIC CLIP APPLIER AND METHOD

BACKGROUND

5 This invention generally relates to an applier for surgical clips. More particularly, this invention relates to a ligating clip applier capable of sequentially delivering a number of clips stored in a clip channel.

Laparoscopic, endoscopic, and other minimally invasive surgical techniques enable surgeons to perform fairly complicated procedures through relatively small entry points in the body. The term "laparoscopic" refers to surgical procedures
10 performed on the interior of the abdomen, while the term "endoscopic" refers more generally to procedures performed in any portion of the body. Endoscopic surgery involves the use of an endoscope, which is an instrument permitting the visual inspection and magnification of a body cavity. The endoscope is inserted into a body cavity through a cannula extending through a hole in the soft tissue protecting
15 the body cavity. The hole is made with a trocar, which includes a cutting instrument slidably and removably disposed within a trocar cannula. After forming the hole, the cutting instrument can be withdrawn from the trocar cannula. A surgeon can then perform diagnostic and/or therapeutic procedures at the surgical site with the aid of specialized medical instruments adapted to fit through the trocar cannula and
20 additional trocar cannulas providing openings into the desired body cavity.

Some known advantages of minimally invasive surgical techniques include reduced trauma to the patient, reduced likelihood of infection at the surgical site, and lower overall medical costs. Accordingly, minimally invasive surgical techniques are being applied to an increasingly wider array of medical procedures.

25 Many surgical procedures require body vessels to be ligated during the surgical process. For example, many surgical procedures require cutting blood vessels (e.g., veins or arteries), and these blood vessels may require ligation to reduce bleeding. In some instances a surgeon may wish to ligate the vessel

temporarily to reduce blood flow to the surgical site during the surgical procedure. In other instances a surgeon may wish to permanently ligate a vessel.

Vessel ligation may be performed by closing the vessel with a ligating clip, or by suturing the vessel with surgical thread. Performing vessel ligation using surgical thread requires complex manipulations of the needle and suture material to form the knots required to secure the vessel. Such complex manipulations are time-consuming and difficult to perform, particularly in endoscopic surgical procedures, which are characterized by limited space and visibility. By contrast, ligating clips are relatively easy and quick to apply. Accordingly, the use of ligating clips in endoscopic surgical procedures has grown dramatically.

Ligating clips may be classified according to their geometric configuration as either symmetric clips or asymmetric clips, and according to the material from which they are manufactured. Symmetric clips are generally "U" or "V" shaped metallic clips that are substantially symmetrical about a central, longitudinal axis extending between the legs of the clip. By contrast, asymmetric clips lack an axis of symmetry. For example, U.S. Patent No. 4,834,096 to Oh et al. describes a polymeric, asymmetric surgical clip in which a first leg member includes a lip that mates with the second leg member to lock the clip in place. Asymmetric clips have certain advantages over symmetric clips. For example, because asymmetric clips are formed from polymeric materials, the mouths of asymmetric clips can be opened wider than the mouths of symmetric clips. This allows a surgeon to position the clip about the desired vessel with greater accuracy. In addition, a clip of the type described in U.S. Patent No. 4,834,096 can be repositioned before locking the clip on the vessel, a process referred to as "approximating" the clip, or to be removed from the vessel.

Ligating clips are applied using mechanical devices commonly referred to as surgical clip applicators, ligating clip applicators, or hemostatic clip applicators. Surgical clip applicators adapted for endoscopic surgical techniques include a shaft adapted to be

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inserted through an endoscopic cannula to access a surgical site in a body cavity and a jaw assembly disposed at the distal end of the shaft for retaining a surgical clip. In use, the clip is positioned over the desired vessel and the jaw is actuated, typically using a mechanism disposed in the handle of the device, to close the clip about the vessel.

Multiple clip applier systems have been developed that enable surgeons to deliver multiple symmetric surgical clips to an endoscopic surgical site. In general, these systems provide a surgical clip channel within the shaft of the device and a mechanism for delivering the surgical clips through the shaft to the jaw assembly. For example, U.S. Patent Nos. 5,100,420 and 5,645,551 to Green et al. describe a device for delivering and applying multiple surgical clips to an endoscopic surgical site. Similarly, U.S. Patent No. Re 35,525 to Stefanchik et al. aims to provide an endoscopic multiple ligating clip applier with a venting system. U.S. Patent No. 5,700,271 to Whitfield et al., European Published Patent Application No. 0 409 569 A1, and European Patent No. 0 596 429 B1 propose other clip applier designs.

As endoscopic techniques have been developed, certain inadequacies in the available surgical equipment have become apparent. For example, the jaws of the applier, which are typically used to close a clip around a vessel, may exert unequal pressure on the clip, resulting in a "scissoring" effect and damage to the vessel. In other instances, the clip may not be properly oriented when it is placed within the jaws or may slip out of alignment during application. This may result in the loss or misapplication of the clip. In still other instances, the applier may jam or may simply fail to deploy a clip.

Further, existing multiple clip applier systems have been designed for symmetric clips and are not well suited to satisfy design issues unique to asymmetric clips. For example, symmetric clips can be retained in clip jaws by holding opposing surfaces of the clip's legs in opposing channels. By contrast, asymmetric clips cannot easily be retained in opposing channels because the clip's legs deform

when the clip is closed. In addition, when symmetric clips are closed on a vessel, the opposing legs of the clip apply substantially even pressure to the opposing sides of the vessel. By contrast, the opposing legs of an asymmetric clip may apply varying pressure to opposing sides of a vessel when the asymmetric clip is closed.

5 Further, locking asymmetric clips of the type described in U.S. Patent No. 4,834,096 function best when force is applied at or near the distal ends of the clip legs. Still further, asymmetric clips of the type described in U.S. Patent No. 4,834,096 may need to be placed under compression to be retained in the clip channel. Thus, conventional clip advancing mechanisms designed for symmetric clips may not
10 reliably advance asymmetric clips. In addition, conventional clip advancing mechanisms designed for symmetric clips may not provide the ability to approximate a clip.

In sum, conventional clip appliers designed for symmetric, metal clips suffer from certain deficiencies and are not adapted to deliver asymmetric, polymer based
15 clips. Accordingly, there is a need to provide an endoscopic clip applier that can reliably deliver a sequence of clips and in a manner which minimizes the risk of damage to the vessel. Further, there is a need for an endoscopic clip applier adapted to deliver asymmetric, polymer ligating clips.

20 SUMMARY

The present invention addresses these and other needs by providing an endoscopic clip applier adapted to retain a plurality of asymmetric ligating clips in a clip channel contained within a shaft assembly, and including a jaw assembly for
25 applying an asymmetric clip. In a preferred embodiment, the jaw assembly is connected to the distal end of the clip channel, and a handle assembly is connected to a proximal end of the clip channel. A feeder bar mounted adjacent the clip channel is moveable between a proximal position and a distal position to advance clips in the clip applier and to feed a clip from the clip channel to the jaw assembly.

Additionally, the shaft assembly is moveable between a proximal position and a distal position, and includes cam surfaces for closing the jaw assembly when the shaft assembly is moved in a distal direction. A trigger on the handle assembly actuates the feeder bar to advance clips in the clip channel and advances the shaft assembly to close the jaw assembly. Advantageously, the shaft assembly may be rotated about its longitudinal axis.

10 In one aspect the invention provides an endoscopic surgical applier having a jaw assembly adapted to establish four separate points of contact with a ligating clip to stabilize the clip in the jaw assembly. Accordingly, the invention provides an endoscopic surgical clip applier that comprises a shaft assembly having a distal end adapted for insertion through a cannula into a body cavity and a clip channel disposed within the shaft assembly for retaining a plurality of clips. A jaw assembly extends from the distal end of the shaft assembly and includes a first jaw member having a first jaw arm for engaging a first portion of a ligating clip and an opposing second jaw arm for engaging a second portion of a ligating clip, the first and second jaw arms each comprising a cam surface, and a second jaw member having a third jaw arm for engaging a third portion of a ligating clip and an opposing fourth jaw arm for engaging a fourth portion of a ligating clip, the third and fourth jaw arms each comprising a cam surface. An actuation assembly advances a clip from the clip channel to the jaw assembly.

25 In another aspect the invention provides an endoscopic clip applier in which cam surfaces on the exterior shaft assembly cooperate with corresponding cam surfaces on the jaw assembly to close the jaw assembly. Accordingly, the invention provides an endoscopic surgical clip applier that comprises an exterior shaft assembly having a proximal end and a distal end adapted for insertion through a cannula into a body cavity and having a plurality of cam surfaces formed at the distal end. A jaw assembly extends from the distal end of the shaft assembly and includes a first jaw member having a first jaw arm for engaging a first portion of a ligating

clip and an opposing second jaw arm for engaging a second portion of a ligating clip. The first and second jaw arms each comprise a cam surface, as do the third and fourth jaw arms. Contained within the exterior shaft assembly are a clip channel adapted to hold a plurality of clips, and a feeder bar for feeding clips from the clip channel to the jaw assembly. An actuation assembly for closing the jaw assembly induces relative motion between the exterior shaft assembly and the jaw assembly so that contact between the cam surfaces closes the jaw assembly.

In yet another aspect the invention provides an endoscopic surgical clip applier that allows a user to approximate a surgical clip before locking the clip on a vessel. Accordingly, an endoscopic surgical clip applier comprises an exterior shaft assembly having a proximal end and a distal end adapted for insertion through a cannula into a body cavity. A clip channel is disposed within the exterior shaft assembly for holding a plurality of clips, and a jaw assembly is connected to the distal end of the clip channel. An actuation assembly includes a trigger for implementing an actuation stroke having a first portion for advancing a clip from the clip channel into the jaw assembly and a second portion for closing the jaw assembly. A ratchet assembly is connected to the trigger, wherein the ratchet assembly precludes reverse motion of the trigger during the first portion of the actuation stroke, but allows reverse motion of the trigger during the second portion of the actuation stroke.

BRIEF DESCRIPTION OF DRAWINGS

Objects and advantages of the invention will be understood by reading the following detailed description in conjunction with the drawings in which:

Figure 1 is a perspective view of a clip applier constructed in accordance with the present invention;

Figure 2a is a perspective view of a shaft assembly of a clip applier in accordance with the present invention;

Figure 2b is an assembly view of the shaft assembly depicted in Fig. 2a;

Figure 2c is an enlarged assembly view of portions of the shaft assembly depicted in Figure 2b;

5 Figure 3a is a cross-sectional view, taken in a plane parallel to the jaw members, of a shaft assembly of a clip applier in accordance with the present invention;

Figure 3b is a cross-sectional view, taken in a plane perpendicular to the jaw members, of a shaft assembly of a clip applier in accordance with the present invention;

10 Figure 4 is an assembly view of a handle assembly in accordance with the present invention;

Figure 5 is a perspective view of the interior of a handle assembly in accordance with the present invention;

15 Figure 6 is a partial cut-away view of a handle assembly in accordance with the present invention;

Figure 7 is a partial cut-away view of a handle assembly in accordance with the present invention;

Figures 8-10 are partial cut-away views of a clip channel during a clip advancing process;

20 Figure 11 is a partial cut-away view of a handle assembly in accordance with an embodiment of the present invention;

Figures 12-14 are perspective views of the jaw assembly during the process of closing a clip;

25 Figures 15a-15c are a perspective views of alternate embodiments of yokes in accordance with the present invention;

Figures 16-17 are perspective views of jaw assemblies in accordance with the present invention;

Figure 18 is a perspective view of a collar in accordance with an embodiment

of the present invention;

Figure 19 is a perspective view of the distal end of a feeder bar in accordance with an embodiment of the present invention;

Figure 20 is a perspective view of the distal end of a clip channel in
5 accordance with an embodiment of the present invention; and

Figures 21-24 are perspective views of an alternate embodiment of a jaw assembly in accordance with the present invention

Figure 25 is a perspective view of an alternate embodiment of a collar in accordance with the present invention.

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DETAILED DESCRIPTION

Referring to Figure 1, an exemplary embodiment of an endoscopic clip applier 10 in accordance with the present invention includes a shaft assembly 20 having a jaw assembly 90 disposed at a distal end and a handle assembly 140 disposed at a proximal end. The handle assembly 140 includes a stationary grip 142 and a moveable trigger 144 for actuating the clip applier 10. In use, the jaw assembly 90 may be positioned inside a body cavity, for example by passing the shaft assembly 20 through an endoscopic cannula, to apply a ligating clip to a body vessel.

20 Figure 2a is a perspective view and Figures 2b and 2c are exploded assembly views of an exemplary embodiment of shaft assembly 20 and jaw assembly 90. Shaft assembly 20 includes a cylindrical outer shaft member 22, which may be formed from two semi-cylindrical outer shaft members 22a and 22b, respectively. It will be appreciated that outer shaft member 22 may be formed from a single tubular
25 member, or may be of a rectangular or polygonal cross-section. Outer shaft member 22 includes a proximal flange 24, indicated by proximal flanges 24a, 24b extending from the cylindrical surface of shaft members 22a and 22b. Outer shaft member further includes pin slots 28a, 28b formed in the cylindrical surface. In addition, the

cylindrical surface of outer shaft members 22a, 22b include opposing channels 26a, 26b that define opposing slots when shaft member 22 is assembled. Outer shaft 22 may be formed from a suitably rigid material, e.g., a suitable polymer or metal.

At the distal end, shaft 22 may taper from a cylindrical cross-section to a substantially rectangular cross-section. A collar 32 (Figure 18) has keys 34a, 34b that interlock with key slots 30a, 30b for connecting the collar 32 to outer shaft member 22. Collar 32 preferably is substantially rectangular in cross-section and includes four cam surfaces 38a, 38b, 38c, 38d and opposing keys 36a, 36b at its distal end. Collar 32 may be formed from suitably rigid material, e.g., a suitable polymer or metal.

A clip feed assembly 70 is disposed within the shaft 22 and collar 32. Clip feed assembly 70 includes a channel 72 for housing clips 78 and feeder bar 80 that is moveable along the longitudinal axis of shaft 22 for moving clips disposed in channel 72 toward the distal end of the applicator 10. Channel 72 includes a pin hole 74 near the proximal end and a plurality of tabs 76 near its base. Channel 72 may be formed from suitably rigid material, e.g., a suitable polymer or metal.

Feeder bar 80 includes a pin slot 82 and a plurality of tabs 84 which act as clip advancing elements to move the clips 78 in channel 72 toward the distal end of the applicator 10. Each tab 84 may be formed by stamping or cutting a portion of the body of the feeder bar 80. The tab 84 remains attached to the body of the feeder bar 80 at the proximal end of the tab 84. Each tab 84 may be bent or otherwise directed toward the interior of the clip channel 72. The tabs 84 may have a substantially uniform length, which may be determined by the length and geometry of the endoscopic clip, and by the rigidity of the material from which the feeder bar 80 is manufactured. The tabs 84 may be located along either the top or bottom (or both) edges of the side of the clip channel. Feeder bar 82 may be formed from suitably rigid material, e.g., a suitable polymer or metal.

Shaft assembly 20 further includes a yoke 50, a portion of which is disposed

within the handle assembly 140, for translating longitudinal motion to feeder bar 80 and outer shaft 22. Feeder bar 80 includes a tab 86 that rests adjacent an interior distal edge 57 of yoke 50 (Fig. 15c). A portion of the yoke body 56 extends along a portion of the length of feeder bar 80 and has a slot 58 that aligns with pin slot 82
5 when yoke 50 is connected to feeder bar 80. Yoke 50 further includes a flange 52 and pin 54 on its proximal end. Yoke 50 may be formed from suitably rigid material, e.g., a suitable polymer or metal. A feeder spring 60 is positioned within the body 56 of yoke 50 for biasing the feeder bar toward the distal end of yoke 50. A tube spring 62 is positioned between flange 52 and a flange 42 on knob 40 for
10 biasing the yoke 50 toward the proximal end of the shaft assembly. A knob spring 64 is disposed within knob 40 and biases the outer shaft 22 in a proximal direction.

A jaw assembly 90 is connected to the distal end of clip channel 72. Jaw assembly 90 includes a first jaw member 92 having a first leg 94 and a second leg 99 connected by a bridge member 104. First leg 94 includes a first cam surface 96 and
15 a first jaw arm 98, and second leg 99 includes a second cam surface 100 and a second jaw arm 102. Bridge member 104 includes a slot 106 for receiving a conventional fastener (e.g., rivets, pins, screws, tabs, etc.) to connect first jaw member 92 to channel 72. Jaw assembly 90 further includes a second jaw member 110 having a third leg 112 and a fourth leg 118 connected by a bridge member 124.
20 Third leg 112 includes a third cam surface 114 and a third jaw arm 116, and fourth leg 118 includes a fourth cam surface 120 and a fourth jaw arm 122. Bridge member 124 includes a slot 126 for receiving a conventional fastener (e.g., rivets, pins, screws, tabs, etc.) to connect second jaw member 110 to channel 72. Jaw assembly 90 further includes a first guide 130 adapted to clip over first jaw arm 98 and third
25 jaw arm 116 and a second guide 132 adapted to clip over second jaw arm 102 and fourth jaw arm 122. Jaw assembly 90 may be formed from suitably rigid material, e.g., a suitable polymer or metal.

Figures 3a and 3b are cross-sectional views of an assembled shaft assembly

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of a clip applicator in accordance with the present invention. When assembled, the jaw assembly 90, clip feed assembly 70, and yoke 50 are connected as described herein and extend through outer shaft 22. Knob 40 is mounted to the exterior of shaft 22 and secured using conventional fasteners (e.g., pins, rivets, screws, adhesives, etc.).

5 A pin 46 extending through knob 40 and through pin hole 74 in channel 72 retains channel 72 in a fixed position with respect to knob 40. For clarity, Figure 3a illustrates a clip channel 72 having a single clip 78, but it will be appreciated that the clip channel 72 may be filled with a plurality (e.g., 2-100) clips. The diameter of shaft 22 is determined by the diameter of the cannula through which the shaft 22 must pass to enter a body cavity. Many existing surgical procedures use a cannula having an inner diameter measuring approximately 10 millimeters. Accordingly, in one embodiment of the invention, the shaft 22 has an outer diameter slightly less than 10 millimeters. In an alternate embodiment, the shaft 22 may be dimensioned to fit within a cannula having a diameter of 5 millimeters. It will be appreciated, 10 however, that the diameter of the shaft 22 is not critical to the invention; any other diameter may be used as desired.

Referring to Figure 4 and Figure 5, a handle assembly 140 includes a fixed grip 142, which may be manufactured in two substantially symmetrical parts 142a, 142b. A trigger 144 is pivotally mounted to fixed grip 142 about a pivot point 146. 15 Trigger 144 includes a grooved claw 148 that impinges on flange 52 to translate the rotary motion of trigger 144 about pivot point 146 to linear motion of yoke 50 relative to fixed grip 142 in the distal direction. Grooved claw 148 also receives the pin 54 of yoke 50. This arrangement enables a user to force yoke 50 in a proximal direction if necessary, which provides a safety feature. Fixed grip 142 further 20 includes a rim 150 that secures the flange 42 of knob 40, such that knob 40 and channel 72 are maintained in a substantially fixed longitudinal position relative to fixed grip 142. The entire shaft assembly 20 is rotatable about its longitudinal axis, and knob 40 includes fins 44 that facilitate rotating the shaft assembly 20. 25

A ratchet key 152 extends from the rear of trigger 144 and contacts ratchet guide 154 to inhibit backward motion of trigger 144 through a portion of the actuation stroke. Preferably, the toothed surface portion of ratchet guide 154 corresponds to the range of motion trigger claw 148 covers while the feeder bar 80 is moved forward to advance the clips in clip channel 72 (i.e., the feed stroke). The smooth surface portion of ratchet guide 154 preferably corresponds to the range of motion trigger claw 148 covers during the portion of the actuation stroke that closes the jaw assembly 90. When the device is actuated, the transition of the ratchet key 152 from the ratchet surface portion to the smooth surface portion provides the user with tactile feedback indicating that the feed stroke is complete and a clip has been fed to the jaw assembly 90. In addition, the smooth surface portion permits a user to approximate a clip.

Basic structural elements of one embodiment of a clip applier 10 have been described with reference to Figures 1-5. The interaction of the structural elements and the operation of the device will be explained with reference to Figures 6-24.

Figure 6 is a partial cut-away, side view of the proximal end of clip applier 10 with the device in an unactuated state. Referring to Figure 6, yoke 50 is biased to its most proximal position by tube spring 62. In the unactuated state, the jaws 90 are partially open, as depicted in Figure 1. Trigger 144 and yoke 50, in combination, may be considered an actuation assembly for actuating the clip feed assembly 70 and the jaw assembly 90.

Figure 7 is a side cut-away view of the proximal end of clip applier 10 with the device in a partially actuated state. Forward motion of yoke 50 places tube spring 62 under compression. In one embodiment, the spring coefficient of feeder spring 60 is higher than the amount of force required to advance the feeder bar 80. Therefore, the feeder spring 60 effectively functions as a solid piece of material during the feed stroke.

According to one aspect of the invention, the first portion of the stroke of

trigger 144 is a feed stroke that advances yoke 50 and feeder bar 80 relative to the fixed channel 72. When the feeder bar 80 is advanced, the tabs 84 engage the clips 78 in channel 72 and advance the clips 78 toward the distal end of applier 10. The most distal clip 78 is fed into the jaw assembly 90. Figures 8-10 are partial cut-away views of the clip feeder assembly illustrating the advance of a position to the most distal during the feed stroke. For clarity of illustration, the distal end of feed bar 80 has been cut-away in Figures 8-10. Figure 8 illustrates the beginning of a feed stroke, in which the tab 84 of feeder bar 80 is brought into contact with a boss 79a of clip 78 disposed in channel 72. In Figure 9, further actuation of trigger 144 moves the feeder bar 80 in a distal direction, which advances clip 78 toward the distal end of channel 72. In Figure 10 the feeder bar 80 has advanced clip 78 to the most distal position in channel 72. For clarity, Figures 8-10 illustrate the advance of a single clip 78 toward the distal end of applier 10, but it will be appreciated that the clip channel may include a plurality (e.g., 2-100) of clips, each of which is advanced by a tab 84 of feeder bar 80. In one embodiment, channel 72 holds twenty (20) clips.

During the feed stroke, the most distal clip is fed from the channel 72 to the jaw assembly 90. According to one aspect, the feeder bar 80 and the clip channel 72 include structure particularly adapted to feed the most distal clip 78 into the jaw assembly 90. In an exemplary embodiment, the distal end of channel 72 and feeder bar 80 include structural features adapted to feed the most distal clip into the jaw assembly 90. Referring to Figure 19, the distal end of feeder bar 80 includes a feeder tab 88 adapted to contact the central, rear portion of the most distal clip to push the clip into the jaw assembly 90. In addition, feeder bar 80 includes a foot member 89 that rotates the rear of the most distal clip during the return stroke so the rear portion of the clip is positioned to contact feeder tab 88. Preferably, the interior surfaces of the jaw assembly that receive the clips are of substantially the same width as the channel 72 to provide a smooth transition between the channel 72 and the jaw assembly 90.

Referring to Figure 20, the distal end of channel 72 includes a tab 71 that catches the boss on the most distal clip 78 when the foot member 89 of feeder bar 80 rotates the clip during the return stroke, thereby limiting the rotation of the clip. In addition, opposing ribs 73a, 73b facilitate centering the rear of the most distal clip (in the lateral direction) so the rear portion of the clip is positioned to contact feeder tab 88. The distal end of channel 72 further includes upper and lower tabs 77a, 77b to provide a surface that facilitates the transfer of the clip 78 into the jaw assembly 90. In addition, opposing lateral tabs 75a, 75b serve to guide the clip 78 into the jaw assembly and to inhibit lateral motion of the rear portion of the clip when the clip is in the jaw assembly 90. Figure 20 also provides a view of tabs 76 that inhibit clips 78 from sliding in a proximal direction during the return stroke of feeder bar 80, and of tabs 79a-79d for securing a jaw member to clip channel 72.

According to another aspect, the applier 10 is configured such that further actuation of the trigger functions to open a clip 78 disposed in the jaw assembly 90. The clips 78 are fed through channel 72 in a compressed configuration, which reduces the required diameter of the shaft assembly 22. The most distal clip 78 is fed into the jaw assembly 90 in the same compressed configuration. As illustrated in Figure 12, hooks 98, 102, 116, 122 limit the forward motion of clip 78 in jaw assembly 90. Therefore, when further pressure is applied to the rear of clip 78 via the feeder tab 88 of feeder bar 80, the force is translated through the legs of clip 78, which causes the jaw assembly 90 (and the clip 78 contained therein) to open wider. The width to which the jaw assembly 90 may be limited by the cam surfaces 38a-38d of collar 34.

Following completion of the feed stroke, further actuation of the trigger 144 actuates the jaw assembly 90. Figure 11 is a side cut-away view of the proximal end of clip applier 10 with the device in a fully actuated state. Pin 46 is always in clearance with the channel 26 in shaft member 22. A rib 149 in handle body 142 limits the forward motion of the claw 148 portion of trigger 144, and hence limits

the forward motion of yoke 50.

Figures 12-14 are perspective views of distal end of applicator 10 illustrating the jaw assembly 90 while it is being closed. Referring first to Figure 12, following completion of the feed portion of the stroke, a clip 78 is positioned in the jaw assembly 90, which is in an open configuration. According to another aspect of the invention, the second portion of the stroke of trigger 144 closes the jaw assembly 90. More particularly, referring to Figures 13-14, the second portion of the stroke moves outer shaft 22 in a distal direction relative to the fixed grip 142, knob 40, and clip channel 72. As the outer shaft 22 and collar 34 are moved in a distal direction, cam surfaces 38a-38d of collar 34 impinge on cam surfaces 96, 100, 114, 120, closing the jaw assembly 90. The use of four separate cams reduces the likelihood of scissoring as the jaw assembly 90 is closed.

While the jaw assembly 90 is closing, the feeder tab 88 of feed bar 80 remains in contact with the rear of clip 78. Closing the jaw assembly tends to drive the rear of clip 78 in a proximal direction, which increases the pressure between the feeder tab 88 and the clip 78 in jaw assembly 90, thereby enhancing the stability of the clip 78 in the jaw assembly. This enhanced clip stability is particularly advantageous when a surgeon is pushing a clip onto a vessel.

Additional features of applicator 10 will be explained with reference to Figures 12-15. Each jaw arm 98, 102, 116, 122 terminates in a hook. The hook of first jaw arm 98 and third jaw arm 116 cooperate to retain boss 79a of clip 78 in jaw assembly 90. Similarly, the hook of second jaw arm 102 and fourth jaw arm 122 cooperate to retain boss 79b of clip 78 in jaw assembly 90. This configuration of jaw assembly 90 provides four distinct points of contact between jaw assembly 90 and clip 78, which reduces the likelihood of the jaw assembly 90 scissoring while it is closing. In addition, this configuration permits the force applied by the jaw assembly 90 to be applied to the distal end of the clip 78, which facilitates locking the clip. The rear (i.e., proximal) portion of clip 78 is retained between tabs 75a,

75b extending from the distal end of clip channel 72, which limits the range of lateral motion available to clip 78. In addition, the feed tab 88 of feed bar 80 prevents the rear (i.e., proximal) portion of clip 78 from being pushed back into the clip channel 72 when the clip 78 is being applied. Accordingly, the clip 78 is
5 maintained stable in three dimensions while retained in the jaw assembly 90.

According to another feature of the invention, only a portion of the ratchet guide 154 includes ratchet teeth. Preferably the length of ratchet guide 154 having teeth corresponds to the feed portion of the actuation stroke of trigger 144. Reversing the direction of feeder bar 80 during the feed stroke may cause the clip to become unstable, or even to fall out of the jaw assembly 90. The teeth on ratchet
10 guide 154 inhibits feeder bar 80 from being moved in a proximal direction during the feed stroke. A second portion of ratchet guide 154, which preferably corresponds to the portion of the stroke during which the jaw is closed, permits the yoke 50 and the outer shaft 22 to move freely in the distal direction and the proximal direction. This allows a user to "approximate" a clip during the closing process, i.e., to partially close a clip then to re-open the jaws to reposition a clip, if necessary.

In another aspect, the distal collar keys 36a, 36b provide a stop to prevent the jaws from unintended closings during use, e.g., under compression as may be incurred during use in the body. Referring to Figure 13 it can be seen that the distal
20 portion of collar keys 36a, 36b include an inwardly-turned segment positioned to block the legs 112 and 118 from closing. However, the leg members 94, 99, 112, and 118 taper inwardly near the distal end of the jaw. Therefore, as illustrated in Figure 14, when the shaft 22 is advanced, the keys 36a, 36b advance past the taper in the jaws, allowing the jaws to close. Additionally, the collar keys 36a, 36b function
25 as cams to facilitate re-opening the jaws after the device is actuated and outer shaft 22 retracts.

Figure 14 illustrates the jaw assembly 90 in a substantially closed configuration. Further actuation of the jaw assembly 90 will lock the clip 78. The

distal motion of outer shaft 22 compresses the knob spring 64 between the flange 24 and the interior distal edge of knob 40, which provides the bias force to return trigger 144 and outer shaft 22 to its unactuated state. After the jaw assembly 90 is closed, the user may release the trigger, and the bias force provided by knob spring 64 urges shaft 22 and feeder bar 80 in a proximal direction. This "resets" the applier 10 back to an unactuated state so that another clip may be fed to the jaw assembly.

During the reset sequence, the tabs 76 on clip channel 72 inhibit the clips 78 in channel 72 from moving in the proximal direction. The tabs 84 on the feeder bar 80 move across the clips 78 in channel 72 and snap into position behind the bosses of the clips. As the feeder bar 80 moves proximally, the foot member 89 of the feeder bar 80 contacts the boss 79b of the most distal clip 78 in the clip channel 72, causing the clip 78 to rotate. Rotation of the most distal clip 78 stops when the boss 79a contacts the most distal tab 84 of feeder bar 80, which preferably positions the rear of clip 78 substantially in the center of the channel 72. As the feeder bar 80 continues to move proximally, the feed tab 88 is positioned adjacent the rear of the most distal clip 78, ready for the next actuation cycle.

Figures 15a-15b illustrate alternate embodiments of a yoke in accordance with the present invention. Fig. 15a is a perspective view of an alternate embodiment of a two-part yoke 180 prior to assembly, and Figure 15b is a perspective view of yoke 180 after assembly. Yoke 180 includes a first body portion 182 and a second body portion 184 connected by a pin 186. The feeder spring 60 may be disposed entirely within the first body portion 182 of yoke 180. In other respects, yoke 180 is substantially similar to yoke 50. Advantages of a two-piece yoke as depicted in Figures 15a-15b include better retention of feeder spring 60 within the body of the yoke and ease of assembly. Figure 15c is a perspective view of yoke 50 depicted in Figure 2, but from the opposite side to illustrate the interior distal edge 57 that receives the tab 86 of feeder bar 80.

Figures 16-17 are perspective views of an alternate embodiment of jaw

assemblies in accordance with the present invention. The jaw assemblies depicted in Figures 16-17 are substantially similar to jaw assembly 90, but may be used with an applier having a shaft assembly 20 with a smaller diameter, e.g., 5 millimeters. The principal distinction between the jaw assemblies depicted in Figures 16-17 and jaw assembly 90 is the elimination of bridge members 104, 124 in favor of making each jaw member a discrete component.

Figures 21-24 are perspective views of the distal end of a clip applier illustrating an alternate embodiment of a jaw assembly 200. Figure 21 illustrates the distal end of the applier with the collar removed to better illustrate the jaw assembly 200. The jaw assembly 200 includes a first jaw member 210 including leg member 212a connected to the clip channel 72 at a pivot point 216a, and leg member 212b connected to the clip channel 72 at a pivot point 216b (not visible) on the opposite side of clip channel 72. Each leg member has a cam surface 214a, 214b. The distal end of the jaw assembly forms a jaw 218. The second jaw member 220 may be substantially identical to the first jaw member 210. Second jaw member 220 includes leg member 222a connected to the clip channel 72 at a pivot point 226a, and leg member 222b connected to clip channel 72 at a pivot point 226b (not visible) on the opposite side of clip channel 72. Each leg member has a cam surface 224a, 224b. The distal end of the jaw assembly forms a jaw 228. Tabs 240, 242 extend from the surface of clip cartridge 72 and function as cams to bias the proximal end of jaw legs 212, 222, respectively, outwardly. This tends to bias the jaw assembly toward a closed configuration.

It will be appreciated that jaws 218, 228 may be opened and closed by pivoting the jaw members about the respective pivot points. Figures 22-24 are sequence views of the distal end of the applier that illustrate closing the jaw assembly. Figure 22 depicts the jaw assembly in the clip feed position, in which the jaws 218, 228 preferably are substantially aligned with surfaces of the clip channel 72 to facilitate the smooth transfer of a clip from the clip channel 72 into the jaw

assembly. As described above, tabs 240, 242 of clip channel 72 bias the proximal end of jaw legs 212, 222 outwardly. Collar 34 limits the outward motion of the proximal end of jaw legs 212, 222, which preferably are dimensioned such that the jaw assembly is at rest as depicted in Figure 22.

5 Figure 23 depicts the jaw assembly in an open configuration. As discussed above, driving a clip in the jaw assembly forward will open the jaw assembly (the clip is omitted in Figure 23 for clarity of illustration). The opening of the jaw assembly is limited by contact between the cam surfaces of the jaw members and the corresponding cam surfaces 38a-38d of the collar 32.

10 Figure 24 depicts the jaw assembly in a closed configuration. As described above in connection with Figures 12-14, when collar 34 is advanced, cams 38a-38d impinge on the cam surfaces 214a, 214b, 224a, 224b, which closes the jaw assembly. Collar 34 includes slots 35a-35d that allow the rear portions of jaw legs 212, 222 to extend outwardly so that the jaws can close.

15 Figure 25 depicts an alternate embodiment of a collar 250 adapted for use with the jaw assembly 200 depicted in Figures 21-24. Collar 250 is substantially similar to the collar depicted in Figures 21-24, and includes a tab 252 that extends into the chamber defined by the collar 250 to prevent the jaws 210, 220 from unintended closing, e.g., due to pressure inside the body cavity. When the jaw
20 assembly is in the unactuated position or the partially-actuated position, tab 252 fits between leg members 212a, 222a to prevent jaw assembly 200 from closing. By contrast, when the assembly is fully actuated, the tab 252 moves distally, allowing the jaw assembly 200 to close.

25 An exemplary embodiment of the invention has been described in which the clip cartridge is retained substantially in a fixed spatial relationship with the fixed grip 142, and the actuation assembly moves the feeder bar 80 to advance clips in the clip channel 72 and outer shaft assembly 20 to close the jaw assembly 90. One of ordinary skill in the art will recognize that the shaft assembly 20 could remain fixed,

and the actuation assembly could move the clip channel 72 relative to the fixed shaft to close the jaw assembly 90. For example, the clip channel 72 could be biased in a distal direction and the pivot point 146 of trigger 144 could be repositioned such that actuating the trigger 144 retracts clip channel 72 in a proximal direction. Similarly,
5 feeder bar 80 could be fixed, such that retracting clip channel 72 in a proximal direction advances clips in the clip channel.

The structure of the clip applier 10 has been generally described in relation to a single embodiment. Alternate embodiments of some components have also been described. It will be appreciated that the alternate embodiments of the components
10 do not substantially alter the steps involved in the operation of the clip applier. In light of this disclosure, modifications to the present invention will be apparent to one skilled in the art. The modifications are intended to fall within the scope of the claims that follow.